# INFLUENCE OF THE 1997 HIGH FLOWS ON THE AQUATIC ECOLOGY OF THE COLORADO RIVER BELOW GLEN CANYON DAM


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## INTRODUCTION

Discharge, suspended sediments, substrata, solar insolation and water temperature are the primary factors influencing benthic community structure in the Colorado River through Grand Canyon. Variability in river discharge can affect the structure and function of benthic communities by altering the stability and availability of substrata (Power et al. 1988, Cobb et al. 1992), water velocity (Peterson and Stevenson 1992), aerial exposure (Blinn et al. 1995), light quantity (Duncan & Blinn 1989) and water quality (Scullion & Sinton 1983). Regulated rivers eliminate seasonal hydrographic changes and remove important life history cues for some aquatic insects thereby reducing diversity (Power et al. 1988).

Statzner and Higler (1986) contend that changes in stream hydraulics are the major determinants in benthic invertebrate distribution, based on the intermediate disturbance hypothesis as outlined by Ward and Stanford (1983) and Reice and co-workers (1990). Under extreme discharge conditions (i.e. Spring run-off) species numbers are relatively low, under less extreme but highly inconsistent conditions (i.e. zones of hydraulic transition) species richness is relatively high due to an overlap of species inhabiting the fringes of their niche requirements. These same criteria may operate in the Colorado River through Grand Canyon if flooding frequency is increased.

High run-off into Lake Powell from 1995 to 1997 resulted in above average releases from Glen Canyon Dam (GCD) for this time period. Starting in June of 1995 the release were fairly constant between 500 - 570 $m^3 \cdot s^{-1}$ through the summer and into the fall. Moderate flows (~350 - 450 $m^3 \cdot s^{-1}$) were released through the winter of 1996 prior to the Spike Flow release in March which had steady low flows (227 $m^3 \cdot s^{-1}$ ) both before and after the Spike Flow. After the Spike Flow, discharges returned to the 500 - 570 $m^3 \cdot s^{-1}$ range, with a steady low flow over the Labor Day weekend and a drop to a typical low fall discharge regime (227-350 $m^3 \cdot s^{-1}$). During the winter of 1997 it was determined that the snow-pack was large enough to require a release above 708 $m^3 \cdot s^{-1}$, the upper limit of the modified fluctuating flow criteria as outlined in the GCD EIS, was required for dam safety. Flows between 680 and 765 $m^3 \cdot s^{-1}$ were released daily fluctuations of <50 $m^3 \cdot s^{-1}$ from February to July when flows were dropped to about 570 $m^3 \cdot s^{-1}$, with minor fluctuations. This complicated release pattern resulted in high steady discharges for the first time since 1985 and for the first time during GCES Phase II and Transition Monitoring Programs. Phase II of GCES occurred during a filling period of Lake Powell with low discharges overall, so these current releases have provided a good opportunity to compare the two different discharge patterns.

The objectives of this study were as follows;

1) Determine what impact these high steady flows have on the benthic community below baseflow (<142 $m^3 \cdot s^{-1}$).

2) Determine what impact these high steady flows have on the benthic community within the varial zone (142 - 565 $m^3 \cdot s^{-1}$).

3) Determine what impact these high steady flows have on organic drift biomass and composition.

4) Characterize the impact of the steady 3 day, 142 $m^3 \cdot s^{-1}$ flows over Labor Day weekend (8/30-9/1/97) have on the benthic community below baseflow and within the varial zone.

5) Calculate recolonization rates of the benthic community within the varial zone in Glen, Marble and Grand Canyons using light as the predictor variable.

## METHODS

Cobble Bars

Collection sites include Lees Ferry Cobble Bar (Rkm 0.8), Two-Mile Wash (Rkm 3.1), Little Colorado River Island (Rkm 98.6), and Tanner Cobble (Rkm 109.6). These sites were chosen to characterize major reaches and to bracket the Paria and Little Colorado Rivers.

Hess substrate samplers will be utilized below baseflow (142 $m^3 \cdot s^{-1}$), and within the varial zone (280 - 500 $m^3 \cdot s^{-1}$ stage). Three paired samples along transects set 30 m apart will be taken within each channel zone ($\underline{n}$=12). Adult and pharate specimens will be collected with sweep nets, white and UV lights, spot samples, and Thienemann collections for taxonomic verification. Abiotic parameters recorded for each sample site will include: water temperature, dissolved oxygen, pH, specific conductance, substratum type, microhabitat conditions, Secchi depth, water velocity or stage, depth, date, site, and time of day.

Light is a critical factor to benthic recolonization, therefore depth integrated light intensity data loggers will be placed near each collection site. Data loggers will be placed 25 cm below the 142 $m^3 \cdot s^{-1}$ stage, 25 cm above the 142 $m^3 \cdot s^{-1}$ stage and near the 765 $m^3 \cdot s^{-1}$ stage, which will serve as the control for ambient light. Benthic biomass estimates rates will be compared between clear and turbid water sites with light as a predictor variable. These data will be integrated into Mike Yard's (GCMRC) primary production model.

Benthic samples will be sorted live into the following 5 biotic categories: C. glomerata, Oscillatoria spp., detritus, miscellaneous algae and macrophytes, and macroinvertebrates. Each biotic category will be oven-dried at 60°C and weighed to determine biomass and converted to ash free dry mass estimates using established regression equations. Multivariate statistical analysis will be employed using abiotic predictor variables and biotic response variables in order to determine patterns in composition, distribution and biomass estimates.

DRIFT

Coarse Particulate Organic Matter (CPOM).

Near-shore surface drift samples (0-0.5 m deep) will be made at each pool site during seasonal collection trips for CPOM. Collections will be made with a circular tow net (48 cm diameter opening, 0.5 $\mu$m mesh) held in place behind a moored pontoon raft or secured to the river bank. Collections will be taken in triplicate between approximately 1000 h and 1500 h at each site to establish the affects of discharge on drift. Samples will be processed live within 48 h and sorted into seven categories including: G. lacustris, chironomid larvae, simuliid larvae, miscellaneous invertebrates, C. glomerata, miscellaneous algae/macrophytes and detritus. Miscellaneous invertebrates will include lumbriculids, tubificids, physids, trichopterans, terrestrial insects and unidentifiable animals. Detritus is composed of both autochthonous (algal/bryophyte/macrophyte fragments) and allochthonous (tributary upland and riparian vegetation) flotsum. Invertebrates will be enumerated, oven-dried at 60°C, weighed, ashed (500°C, 1 h), and reweighed. Current velocity will be measured with a Marsh-McBirney electronic flow meter and collection duration will be measured for volumetric calculations (mass/$m^3$/s). Multivariate statistical analysis will be employed using abiotic predictor variables and biotic response variables in order to determine patterns in composition, distribution and biomass along the river corridor.

Fine Particulate Organic Matter (FPOM drift will be collected at the same time and with the same general protocol as CPOM ($n = 3$). The net has a 30 cm diameter opening with 153 $\mu$m mesh. Samples will be preserved in 70% EtOH and sorted in the lab with a dissecting scope into the following categories: Copepoda (Calanoida, Cyclopoida, Harpacticoida), Cladocera, Ostracoda, and miscellaneous zooplankton which included small chironomids, Gammarus lacustris, planaria, hydra, etc. Large samples will be split with either 1 ml, 5 ml or 10 ml sub-samples sorted from a 100 ml dilution. Zooplankton will be sorted into vials for dry mass estimates, then converted to ash-free dry mass using regression equations. Densities will also recorded. The remaining organic material will be filtered through a 1 mm sieve to remove CPOM and then filtered onto glass fiber filter (Whatman® GF/A) with a Millipore Swinex® system. These filters will be dried at 60°C and combusted for 1 h at 500° C. The condition, reproductive state and presence of nauplii will be documented.

Primary Production

In order to better understand the impact of long term steady high flows and short term steady low flows primary production estimates will be made at Lees Ferry Cobble Bar (Rkm 0.8) and Two-Mile Wash (Rkm 3.1). Samples will be collected below baseflow (142 $m^3 \cdot s^{-1}$), and within the varial zone (280 - 500 $m^3 \cdot s^{-1}$ stage) at each site. Samples consist of three cobbles 25 - 35 cm in circumference placed in a primary production chamber constructed of clear plexiglass ($\underline{n}$=3). Each chamber has a circulating pump (~30 $cm^3 \cdot s^{-1}$) and a dissolved oxygen meter (YSI® model 55). Cobbles are left in the chamber, under ambient light conditions, until a 2 $mg \cdot l^{-1}$ dissolved oxygen change occurs during photosynthesis. The chambers are then placed in a darkened cooler for respiration estimates. Each cobble is scraped of all phyto-benthic growth with a razor knife, dried in the laboratory at 60°C then combusted at 500°C for one h for AFDM estimates. Production estimates are then derived for the entire collection area/stage using equations from Standard Methods (APHA 1992).

## RESULTS AND DISCUSSION

The 1997 discharge regime has resulted in the colonization of the varial zone. Collections were made in October 1996 below the 227 $m^3 \cdot s^{-1}$ stage and subsequent sampling has occurred within the varial zone because of the high water (Figs. 1 and 2). The varial zone was devoid of life in October 1996 but through the next year colonized to biomass estimates that are greater than any collection made below baseflow at any site. We have monthly collections below baseflow at Lees Ferry for primary production estimates, collected by SCUBA, but these data have not been analyzed. The 1997 Labor Day low flows will allow us to assess the benthos below baseflow at all sites.

The typical reduction in benthic biomass with distance from GCD that we have documented in the past is no longer valid (Figs. 1 and 2). Biomass estimates of the phytobenthos are highly variable between sites and seasonally within sites. Although there are fewer macroinvertebrates at Tanner Cobble than Lees Ferry

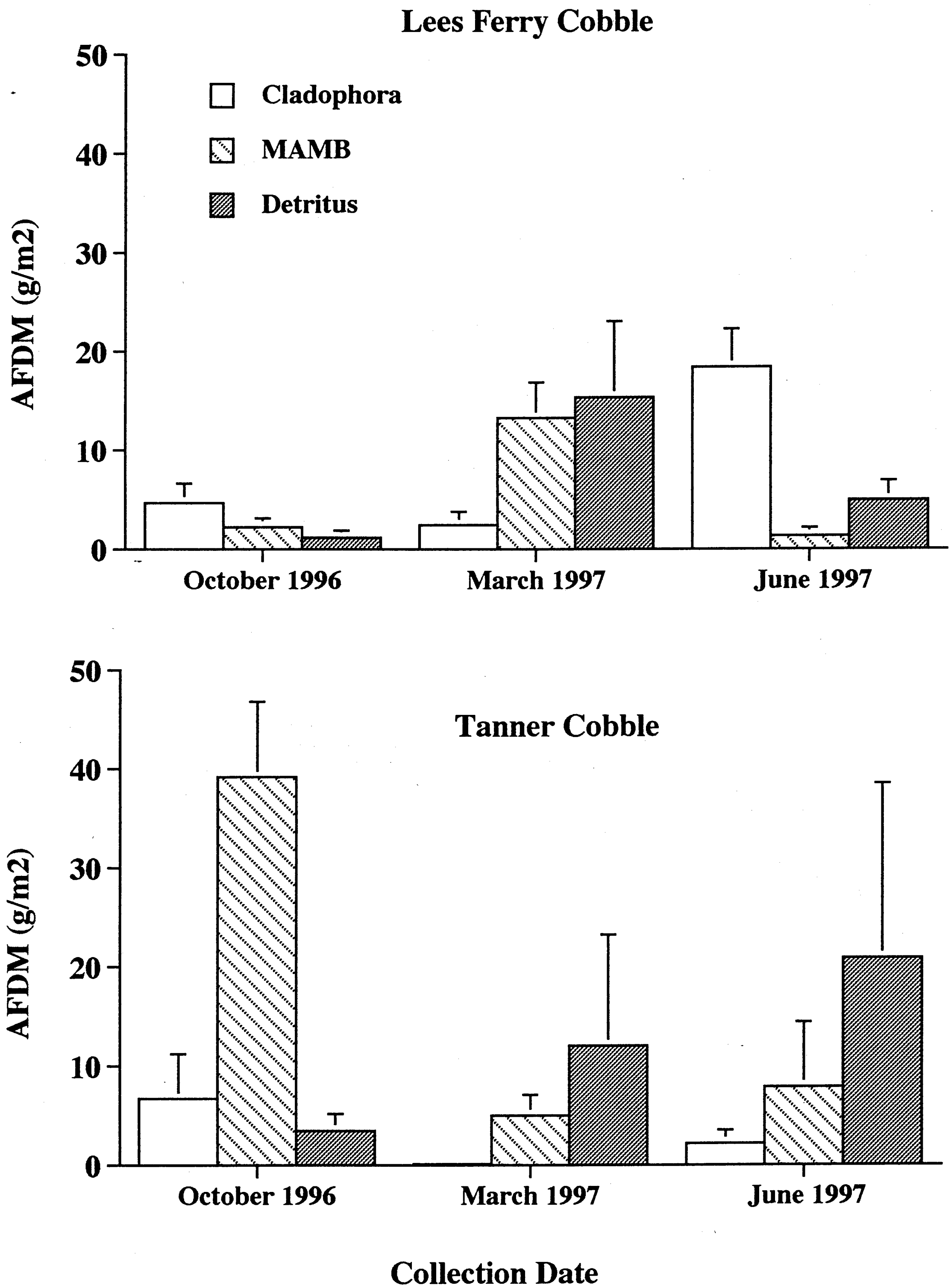


Figure 1. Phytobenthic and detritus biomass estimates from Lees Ferry (Rkm 0.8) and Tanner Cobble (Rkm 109.6) in the Colorado River below Glen Canyon Dam. MAMB represents miscellaneous macrophytes and bryophytes. ( ± 1 SE)

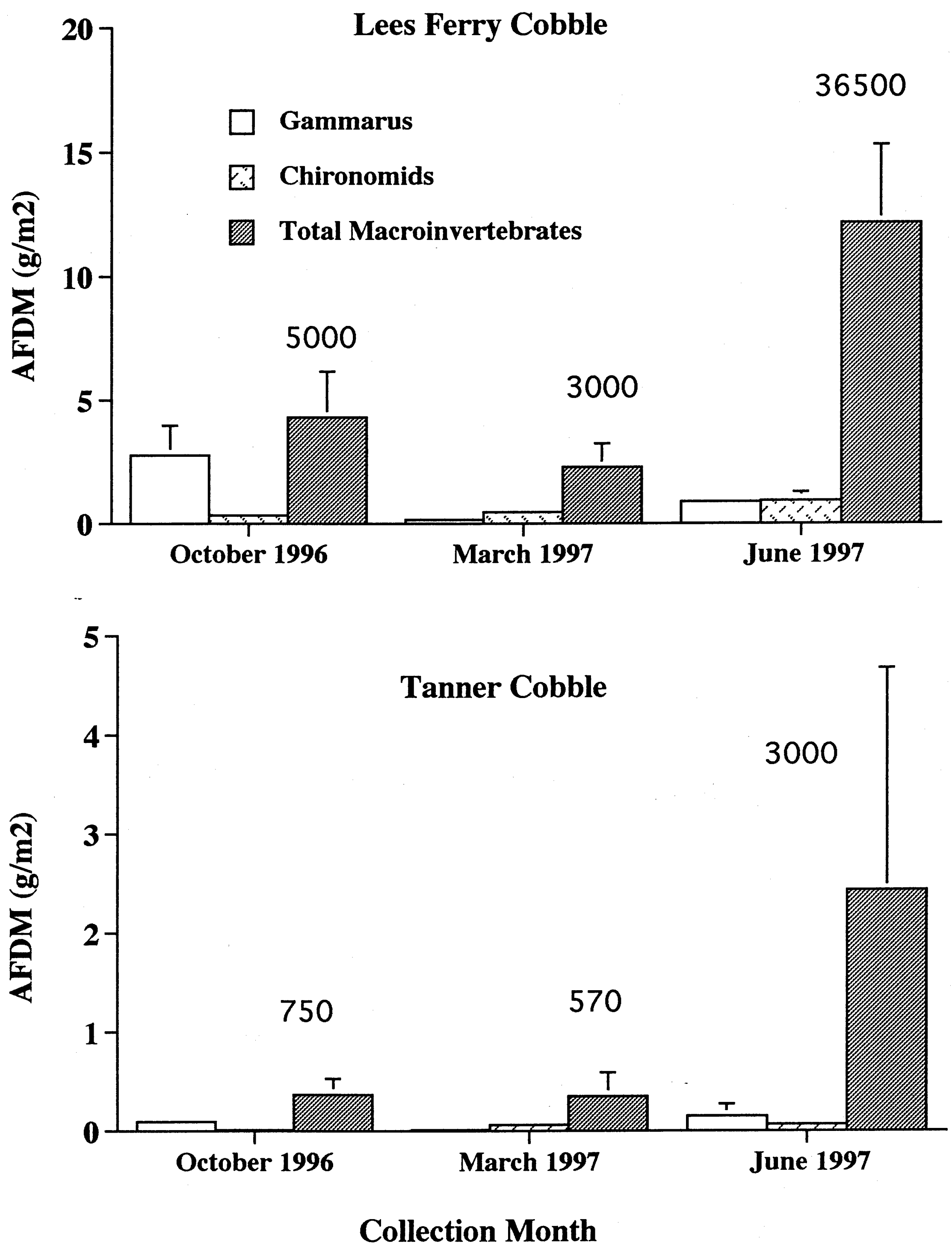


Figure 2. Macroinvertebrate biomass estimates from Lees Ferry (Rkm 0.8) and Tanner Cobble (Rkm 109.6) in the Colorado River below Glen Canyon Dam. Numbers near total macroinvertebrate bars are density estimates (#/m2). Note scale differences in Y-axis. ( ± 1 SE)

for each collection trip, each site has increased in biomass by an order of magnitude during year.

High steady flows appear to enhance benthic growth by reducing light and hydraulic variability. When the tributaries are releasing suspended sediments the higher flows dilute the negative impacts. Apparently continuously low light [photosynthetic available radiation (PAR)], provides a better habitat than variable high light during fluctuating flows.

Collecting up the channel side during the up-coming steady low flows on Labor Day will help us determine if the productive area of the channel has migrated up through the varial zone and be lost during the low flows. This is critical in the down river sites where the impacts of the monsoon run-off will reduce PAR at greater depths.

## LITERATURE CITED

Blinn, D.W., J.P. Shannon, L.E. Stevens and J.P. Carter. 1995. Consequences of fluctuating discharge for lotic communities. Journal of the North American Benthological Society 14:233-248.

Cobb, D.S., T.D. Galloway, and J.F. Flannagan. 1992. Effects of discharge and substrate stability on density and species composition of stream insects. Canadian Journal of Fisheries and Aquatic Sciences 49:1788-1795.

Duncan, S.W. and D.W. Blinn. 1989. Importance of physical variables on the seasonal dynamics of epilithic algae in a highly shaded canyon stream. Journal of Phycology 25:455-461.

Peterson, C.G. and R.J. Stevenson. 1992. Resistance and resilience of lotic algal communities: Importance of disturbance timing and current. Ecology 73:1445-1461.

Power, M.E., A.J. Stewart and W.J. Matthews. 1988. Grazer control of algae in an Ozark mountain stream: effects of short term exclusion. Ecology 69:1894-1898.

Reice, S. R., R,C. Wissmar and R.J. Naiman. 1990. Disturbance regimes, resilience and recovery of animal communities and habitats in lotic ecosystems. Environmental Management 14:647-656.

Scullion, J. and A. Sinton. 1983. Effects of artificial freshets on substratum, composition, benthic invertebrate, fauna, and invertebrate drift in two impounded rivers in mid-Wales. Hydrobiologia 107:261-269.

Statzner, B. and B. Higler. 1986. Stream hydraulics as a major determinant of benthic invertebrate zonation patterns. Freshwater Biology 9:251-262.

Ward, J.V. and J.A. Stanford. 1983. The serial discontinuity concept of lotic ecosystems. p. 29-42. In T.D. Fontaine and S. M. Bartell (eds.), Dynamic of Lotic Ecosystems. Ann Arbor Scientific Publications, Ann Arbor, Mich. 494 p.